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PULSED ELECTRIC FIELD SANITIZATION SYSTEM AND SYSTEM COMPONENTS

This application claims priority to and is entitled to the benefit of United States patent applications 60/439,004 filed Jan. 10, 2003, and 60/482,519 filed June 26, 2003, both of which are incorporated herein by reference.

FIELD OF THE INVENTION

[0001] The present invention relates generally to a pulsed electric field sanitization system, as well as to certain individual components of the system.

BACKGROUND OF THE INVENTION

[0002] Sanitization of drinking water is of great concern, and improperly sanitized water is the cause of many health problems and even death. The effectiveness of a particular method depends on the substance being treated and the type of microbe present. Treatment technologies such as filters are effective against larger organisms, such as *Giardia* and *Crypotosporidum*, allowing other, smaller organisms to pass through. Membrane technology requires higher pressures resulting in a higher electrical cost and associated higher water rejection rate. Ultraviolet light requires extremely low turbidity water and ozone technology requires a long reaction time and thus is not convenient to household use. Additionally, chemical agents have deleterious effects on human health by themselves or via byproducts generated during the sanitization process.

[0003] The following U.S. patents relate to disinfection and/or sanitization processes: U.S. Patent No. 5,851,375 to Bodger, *et al.*; U.S. Patent No. 6,379,628 to de Jong, *et al.*; U.S. Patent No. 6,019,031 to Qin, *et al.*, U.S. Patent No. 5,048,404 to Bushnell, *et al.*; U.S. Patent No. 5,690,978 to Yin, *et al.*; U.S. Patent No. 6,093,432 to Mittal, *et al.*; and U.S. Patent No. 6,086,932 to Gupta.

[0004] A popular household water filtration device is in the style of a pour-through pitcher. Typically, unfiltered water is added to a basin at the top of the device. Through the action of gravity, water percolates through a filtering media (usually consisting of granulated activated carbon) located between the basin and a collection reservoir. Filtered

water is then dispensed from the collection reservoir for drinking. For the general public, gravity-controlled pitcher-type water filtration systems are cost effective.

[0005] One limitation of this kind of device is the inability to filter out and destroy smaller organisms and microbes. To facilitate the flow of water, the filtering media through which water is drawn needs to be of a porous nature. Because of this necessity, such devices do not filter as effectively as other water treatment devices. Part of this inefficiency is caused by a lack of additional purification steps currently available in the prior art, such as ozonation, ultra-violet irradiation, and cell membrane electrofragmentation.

[0006] The filtering media or cartridge used in these pitcher-type filtering systems usually extends down into the collection reservoir, coming in contact with the filtered water. The porosity of the filter media promotes the infiltration, collection and growth of organisms. Thus, there is an increased potential for contamination of the filtered water.

[0007] U.S. Patent No. 5,222,078 issued to Polasky *et al.*, discloses a pour-through gravity-flow pitcher filter.

[0008] U.S. Patent No. 6,103,114 issued to Tanner *et al.*, cites a device which attempts to avoid cross contamination by the design of the spout, pour area and seal between the inner reservoir and the filtered water reservoir. However, the filter in this design still extends into the filtered water reservoir and is a potential source of contamination.

[0009] U.S. Patent No. 6,391,191 issued to Conrad discloses a domestic water treatment appliance with a pump which uses ozone and a carbon block filter to disinfect water, but does not utilize a pour-through filter prior to the ozonation process.

[0010] U.S. Patent No. 6,238,552 issued to Shannon discloses a universal insert for a water purifier with filter on top and bottom and a guide for sliding into a pitcher.

[0011] U.S. Patent Nos. 4,969,996 and 4,306,971 issued to Hankammer discloses a column-like filter device extending into collection reservoir and, thus, yields a potential source of contamination.

[0012] U.S. Patent No. 6,290,848 issued to Tanner *et al.*, discloses a porous particulate filter for removing 99.95% of all 3-4 µm *cryptosporidium* and other protozoan

cysts. U.S. Patent No. 6,103,114, also issued to Tanner *et al.*, describes a carafe-style filter device with a lip over the edge to prevent untreated water from mixing with treated water when pouring.

[0013] U.S. Patent No. 6,405,875 issued to Cutler discloses a carafe-style filter device with an ion-exchange resin and carbon granules which removes 99.95% of all 3-4 μm particles. However, this device extends into filtered water reservoir and thus may be susceptible to contamination.

[0014] As used herein, the term sanitization refers to removal of at least a portion of an unwanted component from a liquid. Such unwanted components may include bacteria and viruses. The term "purification of water" can be referred to interchangeably as "sanitization of water". As used herein, the word disinfection refers to a high level of sanitization, at which the vast majority of live bacteria, viruses and/or other "infective" agents are removed from a liquid.

[0015] All references noted herein are incorporated by reference.

[0016] Thus, there is a need for improvements in sanitation devices that allow convenient access to purified, sanitized or disinfected water.

[0017] Further, there is a need for a stand-alone sanitation device having a gravity filtration component that keeps the filtering media from contacting filtered water. There is also a need for an effective drinking water filtration, purification, or sanitization system that takes advantage of different treatment methods.

SUMMARY OF THE INVENTION

[0018] It is an object of the present invention to obviate or mitigate at least one disadvantage of the prior art water sanitization systems.

[0019] According to an embodiment of the invention, there is provided a pulsed electric field liquid sanitization system comprising: an influent container for housing a liquid to be sanitized; an influent valve within a lower portion of said influent container allowing passage of liquid out of the influent container; an effluent container for housing sanitized liquid; an effluent valve within a lower portion of the effluent container allowing passage of liquid into the effluent container; a housing comprising pulsed electric field electrodes

through which water flows to become sanitized; a pump within the housing to promote movement of fluid therethrough; and an influent container mating component and an effluent container mating component disposed on an exterior surface of the housing. The influent container mating component is positioned upstream of the electrodes and is in fluid communication with the electrodes. The effluent container mating component is positioned downstream of the electrodes and is in fluid communication with the electrodes.

[0020] Further, according to another embodiment of the invention, there is provided a water purification system comprising: a water container comprising an upper reservoir for receiving unfiltered water, the upper reservoir comprising a lower opening; a filtering medium within the lower opening of the upper reservoir for filtering unfiltered water passing therethrough; and a lower reservoir for receiving water passed through the filtering medium, the lower reservoir having a lower opening; and a base for receiving the water container in fluid communication with the lower opening of the lower reservoir. The base comprises a purification technology for purification of water received from the lower reservoir; and a water circulator for circulating water between the lower reservoir and the purification technology.

[0021] Additionally, an embodiment of the invention provides a stand-alone drinking water purification device comprising: an upper reservoir for receiving unfiltered water, the upper reservoir having a lower opening; a filtering medium within the lower opening of the upper reservoir for filtering unfiltered water passing therethrough, the filtering medium being selected from the group consisting of: a granulated activated carbon (GAC) cartridge; an extruded carbon sheet between layers of fabric material; and an ion exchange resin; and a lower reservoir for receiving water passed through the filtering medium. The filtering medium is located above and not extending into the lower reservoir.

[0022] Further, the invention provides in an additional embodiment a pulsed electric field liquid sanitization system comprising: an inlet for interfacing with an influent water source to be sanitized; an outlet for interfacing with an effluent sanitized water receiving means; a housing comprising pulsed electric field electrodes through which

water flows to become sanitized. The housing has the inlet and the outlet disposed thereon, the inlet being positioned upstream of the electrodes and is in fluid communication with the electrodes. The outlet is positioned downstream of the electrodes and is in fluid communication with the electrodes.

[0023] Other aspects and features of the present invention will become apparent to those ordinarily skilled in the art upon review of the following description of specific embodiments of the invention in conjunction with the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] Embodiments of the present invention will now be described, by way of example only, with reference to the attached Figures, wherein:

[0025] **Figure 1** is an isometric view in section of a filter cartridge with a well and an pulsed electric field (PEF) cartridge, according to an embodiment of the invention.

[0026] **Figure 2** is a sectional view of the upper portion of the filter cartridge of Figure 1.

[0027] **Figure 3** is an isometric view of a replaceable pulsed electric field (PEF) cartridge according to an embodiment of the invention..

[0028] **Figure 4** is a sectional view of the replaceable PEF cartridge according to Figure 3.

[0029] **Figure 5** illustrates a bipolar saw-tooth waveform applied to the PEF cell and high voltage transformer driver circuit according to an embodiment of the invention.

[0030] **Figure 6** is an isometric view of an embodiment of a double check valve assembly.

[0031] **Figure 7** is a top view of the double check valve assembly shown in Figure 6, with the cap removed.

[0032] **Figure 8** is a sectional view of the double check valve assembly of Figure 7.

[0033] **Figure 9** is an isometric view of an embodiment of the double check valve assembly of Figure 6 and a mating component.

[0034] **Figure 10** shows a top view of a cap of a double check valve assembly and mating component as shown in Figure 9.. Where item 1 is the double check valve cap.

[0035] **Figure 11** is a sectional view of the double check valve assembly and mating component of Figure 9, taken through line A--A of Figure 10.

[0036] **Figure 12** is a side view of the double check valve assembly and mating component of Figure 9.

[0037] **Figure 13** shows a schematic representation of an embodiment of a system according to an embodiment of the invention.

[0038] **Figure 14** is a front view of a pitcher located on a base according to an embodiment of the invention.

[0039] **Figure 15** shows a schematic representation of a stand-alone drinking water filtration device according to an embodiment of the invention.

[0040] **Figure 16** illustrates a pulsed electric field liquid sanitization system according to an embodiment of the invention.

DETAILED DESCRIPTION

[0041] Generally, the present invention provides a sanitization system and individual components of such a system.

[0042] According to an embodiment of the invention, there is provided a pulsed electric field liquid sanitization system comprising: an influent container for housing a liquid to be sanitized; an influent valve within a lower portion of said influent container allowing passage of liquid out of the influent container; an effluent container for housing sanitized liquid; an effluent valve within a lower portion of the effluent container allowing passage of liquid into the effluent container; a housing comprising pulsed electric field electrodes through which water flows to become sanitized; a pump within the housing to promote movement of fluid therethrough; and an influent container mating component and an effluent container mating component disposed on an exterior surface of the housing. The influent container mating component is positioned upstream of the electrodes and is in fluid communication with the electrodes. The effluent container mating component is positioned downstream of the electrodes and is in fluid communication with the electrodes.

[0043] Optionally, in this embodiment of the system at least one of said influent valve and said effluent valve comprises a double check valve. When present, the double check valve may comprise: an outer body having an inlet and an outlet; first and second valve

stems contained on the outer body; the first valve stem being smaller than the second valve stem, and nested within the second valve stem. The valve stems are positioned along a common axis. The second valve stem comprises a valve seat for the first valve stem; the outlet being the valve seat to the second valve stem; and springs surrounding the first and second valve stems and acting on the valves to engage respective valve seats.

[0044] The system housing may additionally comprise a purification technology positioned between the influent container mating component and the effluent container mating component. When present, this purification technology is in fluid communication with the electrodes. The purification technology may be selected from the group consisting of an ion exchange resin; a filtering unit; a membrane; ozonification means; an ultraviolet (UV) light source; and aeration or oxygenation device.

[0045] The system may additionally comprise electronic controls for detecting the presence of an influent container or an effluent container to activate flow of liquid from the influent container, through the housing and into the effluent container so as to sanitize the liquid.

[0046] Further, according to another embodiment of the invention, there is provided a water purification system comprising: a water container comprising an upper reservoir for receiving unfiltered water, the upper reservoir comprising a lower opening; a filtering medium within the lower opening of the upper reservoir for filtering unfiltered water passing therethrough; and a lower reservoir for receiving water passed through the filtering medium, the lower reservoir having a lower opening; and a base for receiving the water container in fluid communication with the lower opening of the lower reservoir. The base comprises a purification technology for purification of water received from the lower reservoir; and a water circulator for circulating water between the lower reservoir and the purification technology. According to this embodiment, the filtering medium is located above and not extending into the lower reservoir.

[0047] In this embodiment of the water purification system, the water circulator may comprise a pump, connections, and electronic controls. Optionally, the purification technology may be electrodes for generating a pulsed electric field; an ion exchange resin;

a filter; a membrane; ozonification means; an ultraviolet (UV) light source; or an aeration or oxygenation device.

[0048] Optionally, the water purification system may have electronic controls comprising an auto-sensing circuit to detects the presence of the filtration device on the base, to activate a water flow program, and to illuminate a ready light when water purification is complete. The electronic controls may allow activation of a water flow program when a user pushes a start button. The water flow program may comprise a treatment period controlled by time and/or concentration, the treatment period consisting of: a) drawing water from the lower reservoir via a pump, b) pumping water past the purification technology, c) directing water back into the lower reservoir; and/or d) communicating a signal to a user indicating that the water container can be removed from the base.

[0049] Optionally, the filtering medium within the water container may be a granulated activated carbon (GAC) cartridge; an extruded carbon sheet between layers of fabric material; an ion exchange resin; or one or more layers of fabric material.

[0050] The water purification system may comprise a double check valve within the lower reservoir of the water container allowing simultaneous flow of water out of and into the lower reservoir.

[0051] Additionally, an embodiment of the invention provides a stand-alone drinking water purification device comprising: an upper reservoir for receiving unfiltered water, the upper reservoir having a lower opening; a filtering medium within the lower opening of the upper reservoir for filtering unfiltered water passing therethrough, the filtering medium being selected from the group consisting of: a granulated activated carbon (GAC) cartridge; an extruded carbon sheet between layers of fabric material; and an ion exchange resin; and a lower reservoir for receiving water passed through the filtering medium. The filtering medium is located above and not extending into the lower reservoir.

[0052] Further, the invention provides in an additional embodiment a pulsed electric field liquid sanitization system comprising: an inlet for interfacing with an influent water source to be sanitized; an outlet for interfacing with an effluent sanitized water receiving means; a housing comprising pulsed electric field electrodes through which water flows to become sanitized. The housing has the inlet and the outlet disposed thereon, the inlet being

positioned upstream of the electrodes and is in fluid communication with the electrodes. The outlet is positioned downstream of the electrodes and is in fluid communication with the electrodes.

[0053] The invention provides a sanitization system for drinking water. According to an embodiment of the invention, the system comprises a base, and dirty and clean water containers that are either stationary or permanent. The dirty and clean water containers may be referred to interchangeably herein as "influent" and "effluent" containers, respectively. The base contains a pump and the required connections and electronics. A filter housing is provided which incorporates a double check valve, which interfaces with the base and allows for a single connection point. The dirty water container can also contain such a double check valve and can be used as a treatment chamber. The base auto-senses that a container is connected and a dispensation arm activates sanitization and dispensation processes. The influent water passes between a set of electrodes so that the water is in contact with the electrodes. A waveform of a given voltage, pulse width and frequency is applied across the electrodes such that a voltage gradient of at least one volt is produced across the membrane of any cell in the water. This causes a breakdown of the cell membrane.

[0054] ***Electrodes.***

[0055] The difference between the present invention and prior art systems is that the invention positions electrodes within a disposable container, such as a disposable cartridge, which may be replaced on a regular basis. This ensures that the condition of the electrodes is optimum at all times. This allows the technology to be affordable by the use of common, less expensive materials for the electrodes. Copper electrodes are also beneficial due to the biostatic effect of copper on microorganisms. The replaceable electrodes allow the arcing condition of the electrodes to be present and simplifies circuitry and monitoring in the system. The electrodes may also be configured to be an easily replaceable unit once again allowing for the use of common materials and allowing the arc condition to exist in the system. The electrode configuration also incorporates a well design to ensure that water is always present to prevent localized water boiling and related pressure issues.

[0056] According to an embodiment of the invention, a sanitization system for drinking water comprises a base containing a pump and the necessary connections and electronics; an autosensing circuit for detecting the presence of an influent or effluent container, and which activates the sanitization process. The influent container comprises either a double or single check valve in its base, which interfaces with a receptacle in the base and allows the container to be removed without leaking. The filter housing incorporates a double check valve in its base, which interfaces with a receptacle in the system base, and allows the container to be removed without leaking. The check valve allows water to flow out of and back into the container without requiring additional connections. Water from the container flows out by a pump or other means, through an ion exchange resin, a prefiltering media, a secondary filtering media, and through the electrodes, thereby dispensing disinfected water into the effluent container.

[0057] The influent water container can be used as a treatment chamber where the influent water is pumped from said container, through the process and dispensed back to the influent container awaiting dispensation into drinking or storage vessel.

[0058] The electrodes are in the form of at least one pair, and may be either sacrificial or non-sacrificial in nature.

[0059] The electrodes may be in the form of parallel rings separated by a distance of at least 0.010" and no greater than 0.120" such that water flows between said electrodes and exit through center of one ring electrode. The electrodes may be continuous co-planar rings or non-continuos co-planer rings.

[0060] The voltage gradient may be, for example in the range of from 120 V to 100,100 V, as in the case of an industrial-scale system. A preferred range is from 2,500 V to 10,000 V AC. The frequency of waveform may be in the range of from 1 to 100 kHz. A preferred range is from 2 kHz to 50 kHz.

[0061] The pulse width of the waveform may be any acceptable width, for example, from 1 to 50 microseconds. A preferred range is from 2 to 10 microseconds.

[0062] The waveform may be a bi-polar square wave, or a modified bi-polar saw tooth wave (instantly reversing).

[0063] The electrodes can arc, as the electronics will control system to protect from arcs and restart system when safe. The electrodes may be positioned inside the filter housing. The electrodes may be replaced each time filter is replaced. The electrodes are protected from clogging by being placed inside the filter.

[0064] The electrodes can erode due to replacement schedule, making electrodes more cost effective and the system more cost effective.

[0065] The electrodes may be positioned at the bottom of a well to ensure that sufficient water is between electrodes and to prevent the water from boiling.

[0066] One benefit of having the electrodes inside the filter housing is that the electrodes can be the extruded carbon block filter. This means that the electrode may also act as a filtering media. Either electrode can be made from the extruded carbon block or both can be of carbon block.

[0067] The electrodes may be powered from a standard electrical main, for example having 120 V / 60 Hz. The electrodes may be power efficient, with an average power consumption of 0.8 Amps, for example.

[0068] The electrode configuration may be a replaceable cartridge, allowing for a cost effective system.

[0069] An ion exchange resin, to lower conductivity of the water, may be placed inside the filter housing. The ion exchange resin may be exchanged every time filter is exchanged. The ion exchange resin may act as a preliminary filter.

[0070] The pre-filter may be formed of the ion exchange resin and mesh media wrapped around an extruded carbon block. The secondary filter may consist of an extruded carbon block. The extruded carbon block can be of multiple formulations, dependent on influent water. The ion exchange resin, pre-filter and secondary filter can be disposed in separate housings.

[0071] The electrodes may have any acceptable configuration, provided the water flows past the electrodes and is provided with adequate exposure to effect sanitization of the water.

[0072] **Figure 1** is an isometric view in section of a replaceable filter cartridge (100) according to an embodiment of the invention. The cartridge has a dual check valve (102)

at its base, and a filter housing cap (104) positioned on top of the filter housing (106). The cartridge houses a carbon block filter (108) having a prefilter wrap (109) on the outersurface. Adjacent to the carbon block fileter is area to house ion exchange resin (110). The ion exchange resin may be disposed with in the cartridge either on the interior of the carbon block filter, or may alternatively be outboard of the ion exchange (as illustrated here). A pulsed electric field (PEF) cartridge is shown (112) and is represented in detail in **Figure 3**. A water entrance tube (114) and water exit tube (116) are illustrated.

[0073] **Figure 2** is a sectional view of the upper portion of the filter cartridge of **Figure 1**. This view illustrates the filter housing cap (104), the area to house ion exchange resin (110), the carbon block filter (108), entrance tube (114), PEF well (202) surrounding the PEF cartridge (112), an annular gap (204) surrounding the PEF, allowing water to pass through, and a exit tube (116).

[0074] The water path is such that water enters the filter cartridge (100) through the double check valve (102), into the ion exchange resin (110), then passes through the prefilter wrap (109) and then through the carbon block filter (108). After passing through the carbon block filter, the water travels up the entrance tube (114) which is formed by the annular area formed between the inner diameter of the carbon block filter and the OD of the exit tube (116). Water then fills a PEF well (202) and is channelled through the annular electrodes in the PEF cartridge (112) as shown in **Figure 4**. After passing through the annular ring configuration within the PEF cartridge (112), the water is channelled to the double check valve (102) via the exit tube (116).

[0075] **Figure 3** is an isometric view of a replaceable PEF cartridge (300) according to an embodiment of the invention that may be used within a replaceable filter cartridge, for example as shown in **Figure 1**. The cartridge has a cartridge cap (302), an top o-ring (304), a cartridge body (306), and a bottom o-ring (308).

[0076] **Figure 4** is a sectional view of the replaceable PEF cartridge according to **Figure 3**. Illustrated in this view are the well area (402) where water is held prior to passing by the electrodes, an annular gap (404) between the annularly arranged electrodes for water to flow therethrough, an outer electrode (406), and an inner electrode (408).

[0077] **Figure 5** illustrates a bipolar saw-tooth waveform applied to the PEF cell and high voltage transformer driver circuit according to an embodiment of the invention. The pulse width of the waveform can be observed.

[0078] A double check valve component which may be used in combination with this system, is described in detail below.

[0079] *Double Check Valve.*

[0080] The double check valve assembly according to the invention allows the control of fluids, and in particular, but not limited to, the control of fluids into and out of a container. The container may be permanently mounted or removable and the flow into and out of the container may occur simultaneously or sequentially.

[0081] Check valves are used in a variety of applications where fluid flow needs to be restricted in one direction. Examples include the filling and emptying of tanks and the control of fluid flow in conduits such as pipes. However, if flow is required in two directions simultaneously, for example flow into and out of a tank, two separate check valves are required, and thus two openings are required in the tank.

[0082] The double check valve allows two independent flows to occur either simultaneously or alternately through the same check valve assembly.

[0083] The double check valve allows two separate and independent flows to occur through a single check valve assembly. In addition, devices such as caps can be added to improve flow separation and improve mixing through the use of flow diverters that impart rotational flow. Also, the check valve assembly can allow the tank to be removed from an interface and prevents the fluid from leaking from said tank. The two valve stems within the check valve assembly can be operated independently or co-operatively.

[0084] The double check valve may include a first and second check valve operated independently and having first valve contained within the second. Two independent fluid flow paths are thus created, one flowing through the second valve stem and around the first, and a second flow around the second valve stem.

[0085] According to one embodiment, the double check valve assembly includes an outer body having an inlet and an outlet with the first and second valve stems contained in the outer body. The outlet of the outer body is the valve seat to the second valve stem. The

first valve stem is smaller than the second valve stem, and is contained within the second valve stem and operated along a common axis. The second valve stem has a cylindrical conduit passing through it in which the first valve stem is contained, and also contains the valve seat for the first valve stem. Fluids can thus pass around the first valve stem and through the second. Individual springs surround the first and second valve stems. These springs act on the valves to engage their respective valve seats. The first and second valve stems can be actuated independently or co-operatively.

[0086] When the valves are open, two independent fluid flows are created, one flow around the second valve stem and through the outlet in the outer body, and one through the second valve stem and around the first valve stem.

[0087] The double check valve assembly according to this embodiment are integral to the wall of a fluid container either permanently mounted or mobile, requiring the control of the input and/or output of a fluid. Different container types for use with the invention are described elsewhere. Preferably, the valve is integral to the lower wall (floor) of the container.

[0088] The first valve stem may optional have a cylindrical conduit formed partially through it allowing fluids to pass through the conduit when the first valve stem is unseated from its valve seat.

[0089] The outer body may optionally incorporate one or more protrusions that are arranged radially and surround the outlet and the first and second valve stems. These protrusions may take the form of mounting bosses or flow diverters. In the case where the protrusions are flow diverters, these may be configured to impart a rotation motion to the fluid exiting around the second valve stem. In the case where the protrusions are mounting bosses, such mounting bosses are used to mount a removable cap to the outer body and over the first and second valve seats. In such an embodiment, the cap may contains flow diverters, a centrally located conduit and a valve seat.

[0090] The cap may be mounted to the mounting bosses, in which case the flow diverters contained in the cap create channels through which fluid will flow. The flow diverters may impart a rotation motion to the fluid. When the first and second valve stems are open the second valve stem seats against the valve seat in the cap and the first valve seat passes into

the conduit formed through the center of the cap. Thus two flow paths are effectively divided. One flow around the second valve stem, under the cap and through the flow diverters and the other flow through the conduit in the center of the cap and around the first valve stem.

[0091] **Figure 6** is an isometric view of an embodiment of a double check valve assembly (600). The double check valve assembly has a cap (602) disposed on the surface facing the interior of the container in which the assembly is placed. The cap is optional, but when present serves to facilitate mixing within the container. Beneath the cap are fan-shaped blades (604) that promote movement of the water that passes by the blades. The first valve runs through the central axis of the assembly, allowing fluids through in a downward flow. The first valve has a first valve inlet (shown in **Figures 7** and **8**) and a first valve outlet (606). The second valve is formed in an annular configuration around the first valve, and allows return flow (upward) of fluids. The second valve inlet (608) is disposed at the lower end of the assembly, and the second valve outlet is at the upper end of the assembly, beneath the cap, as shown in **Figures 7** and **8**.

[0092] **Figure 7** is a top view of the double check valve assembly shown in **Figure 6**, with the cap removed. This view more clearly illustrates the fan-shaped blades (604), configured beneath the cap. The first valve inlet (702) and the second valve outlet (704) are visible when the cap is removed.

[0093] When the cap is not present, the double check valve retains the same function, but may have less thorough mixing of fluids within the container.

[0094] **Figure 8** is a sectional view of the double check valve assembly (600). The first check valve stem (802) is shown to be nested within the first check valve inlet (702). The second valve stem (804) is shown outboard of the first check valve inlet (702). A first valve stem o-ring (806) is shown disposed around the first check valve stem. An second valve stem o-ring (808) is shown to encircle the second valve stem. A second valve stem spring (810) is shown, along with an first valve stem spring (812). Outer body o-rings (814) is present on the exterior of the double check valve assembly to allow a sealed (and removable) connection of the assembly with a mating component.

[0095] **Figure 9** is an isometric view of an embodiment of the double check valve assembly (600) of **Figure 6** and a mating component (902). The mating component allows formation of a reservoir for fluids from the first and second check valve. A center tube (904) to allow flow of fluid out of the first check valve, while a return flow tube (906) allows fluid to flow into the second check valve. In this embodiment, the double check valve assembly and the mating component are lodged together removably, and the interface between these components is sealed by the outer body o-rings, shown in **Figure 8.**

[0096] **Figure 10** shows a top view of the double check valve assembly and mating component as shown in **Figure 9.** The cap (602) is shown to have the connection points (1002) by which the cap is fastened to the fan-shaped blades. The first valve inlet (702) and second valve outlet (704) are shown.

[0097] **Figure 11** is a sectional view of the double check valve assembly and mating component of **Figure 9**, taken through line A--A of **Figure 10.** The first valve stem (802), the second valve stem (804), the first valve stem o-ring (806), the second valve stem o-ring (808), the second valve stem spring (810), the outer body o-rings (814), and the first valve stem spring (812) are shown. Additionally, a center conduit o-ring (1102) is shown, which allows sealing of the assembly to the mating component. As can be seen in this sectional view, fluid flowing into the first check valve flows through the center tube (904) for further processing, whereas fluid flows through the return flow tube (906) and into a center reservoir (1104), while awaiting return through the second check valve. When the double check valve assembly is disconnected to the mating component, the fluid is not allowed to flow upward through the second check valve. Only when the double check valve assembly is mated to the mating component is fluid allowed to flow out of the center reservoir. This advantageously allows fluid to be held back if a container is not in place upon the base.

[0098] **Figure 12** is a side view of the double check valve assembly and mating component of **Figure 9.** The cap (602), center tube (904), return flow tube (906), and central reservoir (1104) can be seen. In this embodiment, the return flow tube enters from an angled off-set position into the central reservoir, which promotes mixing of fluid in the

central reservoir. The top portion (1202) of the mating component is indicated, illustrating the region where the double check valve interfaces with the mating component.

[0099] *Gravity-Fed Filter.*

[00100] In addition to the electrodes used to sanitize liquids within the system, the invention may include a gravity-fed filter device. In such an embodiment, a gravity-fed filter may be an extruded carbon filter between fabric, a non-extruded carbon filter, or a fabric filter without any activated carbon. The gravity-fed filter is located above a filtered water reservoir. Preferably, the gravity-fed filter does not extend into the water within the filtered water reservoir. However, the system may include a gravity-fed filter that extends downward into a filtered water reservoir, as well as a filter that does not. According to an embodiment of the invention, the system comprises a gravity-fed filter in combination with a pair of electrodes. Such a filter may be a composite cartridge, or these two technologies can be provided in serial.

[00101] Additional sanitization or purification technologies can optionally be used in addition to the electrodes, such as an ozonification means; ultra, micro and nanofiltration; or an ultraviolet (UV) light source; and aeration/oxygenation. The purification technology is appropriately arranged so as to act on the water within the filtered water reservoir. Such a system may comprise a pitcher mounted on a base, or may be housed within a water cooler, a juicer, a coffee maker or any other device in which pre-conditioning of water is desirable. The system may be a portable unit. Further, the system may be a plumbed in system, where a float arrangement can be used to supply water to the gravity-fed filter.

[00102] The embodiment of the invention involving gravity filtration comprises a drinking water filtration device having an upper reservoir for receiving unfiltered water. The upper reservoir has a lower opening; a filtering medium within the lower opening of the upper reservoir for filtering unfiltered water passing therethrough; and a lower reservoir for receiving water passed through the filtering medium. The lower reservoir has a lower opening. Also, a base is included for receiving the drinking water filtration device in fluid communication with the lower opening of the lower reservoir. The base comprises a purification technology for purification of water received from the lower reservoir. The

system also includes a water circulator (or pump) for circulating water between the lower reservoir and the purification technology within the base.

[00103] According to an embodiment of the invention, there is also provided a gravity-fed filtration device that is a stand-alone filtration device using an extruded carbon filter which does not extend into the water that has passed through the filter. As a stand-alone filtration device, an extruded carbon filter is located above a filtered water reservoir, and may be disposed between an upper and a lower fabric sheet. In this embodiment, the filter does not extend into the filtered water reservoir. Thus, once water passes through the filter and into the filtered water reservoir, there is no further contact with the filter. Such a stand-alone filtration device can be a pitcher, a water cooler, a juicer, a coffee maker or any other device in which pre-conditioning of water is desirable. The device may be a portable unit, or may incorporate a plumbed in unit, where a float arrangement is used to feed the filter.

[00104] The embodiment of the invention that is a stand-alone device provides a drinking water filtration device comprising an upper reservoir for receiving unfiltered water; the upper reservoir having a lower opening. A filtering medium is also included, located within the lower opening of the upper reservoir for filtering unfiltered water passing therethrough. The filtering medium is selected from the group consisting of: a granulated activated carbon (GAC) cartridge; an extruded carbon sheet between layers of fabric material; and an ion exchange resin. Also, a lower reservoir is included for receiving water passed through the filtering medium. In this embodiment, the filtering medium is located above and not extending into the lower reservoir.

[00105] **Figure 13** schematically illustrates an embodiment of the system of the invention in which the filtration device is used in combination with another purification technology. In this case, the water container (1311) is a removable component of a multi-technology water filtration system (1320). The container rests on a base (1322). The base contains a pump, a venturi, connections, control electronics, and a purification technology (1324) comprising at least one of a variety of purification technologies. The purification technology may include a pair of electrodes, as described above, and may also include any other acceptable sanitization or purification technologies such as i) an ozonification means

(having an ozone generator, an ozone destructor and a centrifugal degasser), ii) filtration (one or more of ultra, micro, or nanofiltration), iii) an ultraviolet (UV) light source, or iv) aeration/oxygenation which can incorporate a sparger type media for releasing bubbles and optionally, a plastic deflector can be used to aid in circulation in the embodiments for which aeration/oxygenation is used as a purification means. Aeration can be used alone simply to alter aesthetic qualities of water. A double check valve (1326) is located at the interface of the water container and the base to ensure appropriate flow of water.

[00106] In this system, control electronics within the base can incorporate an auto-sensing circuit to detect the presence of the water container on the base, and can activate an appropriate program depending on whether the container is present or absent. A user can activates the purification technology by pressing a button.

[00107] The pump within the base draws water from the lower reservoir and pumps it through a venturi. In the case where ozone purification is the purification technology employed, the venturi has a gas inlet which draws air through an ozone generator. The venturi in the base imparts a rotary motion to the entire flow and creates an annular flow through the injection portion causing a larger portion of the flow to reach high velocity and a larger portion of the flow to directly contact the secondary fluid.

[00108] A centrifugal gas-liquid separator may be used with the base, which includes an integrated gas release valve. This separator allows the removal of entrained gasses from a liquid flow. A liquid-gas mixture is injected tangentially into a helical channel which initiates a high velocity vortex. The vortexing liquid-gas mixture rises up the tube and under centrifugal force the gas is forced to the centre of the vortex and the liquid is forced to the periphery. As the liquid-gas mixture rises in the tube, a slot around the tube draws off a portion of the liquid, which is discharged through a liquid outlet. The remaining liquid-gas mixture rises into the valve chamber. The liquid level in the valve chamber interacts with a float that opens and closes a port releasing the gas as needed.

[00109] In one embodiment, the ozone generator may be a corona-discharge type, and converts a portion of the oxygen in the air into ozone. The ozone is mixed with the water in the venturi. The water ozone mixture then passes into a centrifugal degasser, which removes the air and undissolved ozone. The removed gas may be disposed of, destroyed,

or re-used as desired. In the case where ozone is destroyed, gasses may be directed to an ozone destructor, which converts ozone into oxygen and safely releases it into the atmosphere. Alternatively, the gas may be sent back to the inlet of the ozone generator or to the inlet of the venturi for recycling within the system. Optionally, the gas may be relaesed to the atmosphere, if it is deemed appropriate for the particular jurisdiction in which the system is used. Many countries have no specific regulations determining acceptable levels of ozone emission into the atmosphere.

[00110] In some embodiments, the liquid-gas separator directs expelled gas back into the inlet of the venturi to be redissolved into the water, or into the inlet of the ozone generator. The ozonated water leaves the liquid-gas separator and is directed back into the fluid container. The cycle continues until a predetermined time and/or ozone concentration is reached. An ORP sensor is located at the inlet of the system which continuously monitors the level of ozone in the water and may be used to control the process cycle of the unit.

[00111] In another embodiment of the system according to the invention the base may incorporate an electric field created across a pair of electrodes as the purification technology. In this embodiment, purification may proceed by creating a voltage potential across the membrane of a single organism, for example a potential of 1 volt. The voltage potential causes the membrane to rupture and effectively killing the organism.

[00112] In a further embodiment, the base contains a purification technology employing a membrane of either ultra, micro or nanofiltration. The membrane has an effective opening, and organisms (such as those found in drinking water) are trapped by the membrane structure and removed from the drinking water.

[00113] In yet another embodiment, the base contains an ultraviolet (UV) light source as the purification technology. In this embodiment, UV light is passed over water which has flowed out by a pump or other means from the lower reservoir of the water container, and back into the lower reservoir of the container.

[00114] In yet another embodiment, the base contains a venturi which draws in atmospheric oxygen or pure oxygen to aerate and/or oxygenate the water. In this case, aeration/oxygenation is the purification technology employed. This aeration and/or oxygenation purification may also employ a sparger system in the base of the container.

[00115] Regardless of the selected purification technology, the system pumps water through the purification means, and water is then is directed back into the lower reservoir. The cycle may be allowed to continue until a predetermined time or purity is reached. A light and/or audible alarm may be employed to indicate to a user when the purification process is complete, and that the container can be removed.

[00116] The system according to the invention incorporates a double check valve at the interface of the water container and the base, which allows the container to be removed without leaking. This arrangement allows water to flow out of and into the container simultaneously while using a single connection point. Water flows from the lower reservoir of the container via a pump (or similar means), through a venturi, through the purification technology and back into the lower reservoir of the container.

[00117] **Figure 14** illustrates a front view of an embodiment of the system according to the invention in which a pitcher (1430) has a flat extruded carbon sheet (1432) between fabric as a filter media. The extruded carbon sheet is located in the floor of an upper reservoir (1434). A lid (1436) is provided to cover the upper reservoir. Water received in the upper reservoir (1434) slowly filters through the extruded carbon sheet 32 and runs through into lower reservoir of the pitcher. A sparger medium (1438) is located within the lower reservoir at the bottom of the pitcher, and is adapted for communication with an air pump (1440). The pitcher is adapted to sit in a specific location on a base (1442) through which the air pump provides air. The air pump provides air to the sparger medium, thereby releasing bubbles into the water held within the pitcher, allowing purification of water. In this embodiment, a plastic reflector (1444) is disposed above the sparger medium to aid in circulation of bubbles. In practice, this allows purification of water both by filtration through the extruded carbon filter and by aeration/oxygenation through the pump located in the base with which the pitcher communicates. Similar to the schematic shown in **Figure 13**, a double check valve is incorporated in this embodiment to ensure that appropriate flow of water into and out of the pitcher is accomplished. Electronic controls may be used within the base to allow detection of the pitcher on the base. Although the extruded carbon filter is illustrated as not extending below the floor of the upper reservoir, it is to be understood that when used in combination with a base

having other purification technologies, it is possible to use an extruded carbon filter that extends below the floor of the upper reservoir, and into the water contained in

[00118] **Figure 15** shows a schematic representation of a stand-alone drinking water filtration device according to an embodiment of the invention. The device comprises a water container (1511) and filtering media (1513). Unfiltered water is added to an upper reservoir (1512) at the top of the container, which in this case is shown as a pitcher. Water is gravity-fed through the filtering media which is located within the upper reservoir at the top of the container. Thus, the filtering media is not in contact with water already filtered, which has passed through into the lower reservoir (1514). When used as a stand-alone device, the filtering media preferably comprises an extruded carbon sheet between the layers of fabric material. In other embodiments, especially when the device is part of a system, the filtering media may comprise a cartridge of granulated activated carbon (GAC), an extruded carbon sheet between the layers of fabric material, an ion exchange resin with or without a GAC or extruded carbon sheet, or one or more layers of fabric material without carbon for prefiltration purposes. In this schematic illustration, water is gravity-fed through the filtering media and is held in the lower reservoir until use.

[00119] **Figure 16** is a schematic representation of a pulsed electric field liquid sanitization system (1600) according to a preferred embodiment of the invention. The system comprises an influent container (1602) for housing a liquid to be sanitized (1604). The container may be of any acceptable type, and may be refilled by a user, or automatically refilled by a water source without intervention from a user. The system includes an influent valve (1606) within a lower portion of the influent container, allowing passage of liquid out of the influent container through the valve. An effluent container (1608) for housing sanitized liquid (1610) is present. An effluent valve (1612) is located within a lower portion of the effluent container, allowing passage of sanitized liquid into the effluent container.

[00120] The system (1600) includes a housing (1614) comprising pulsed electric field electrodes (1616), which may be contained within a unit, such as a cartridge which may be disposable or replaceable. Water flows past these electrodes (through the unit) so as to become sanitized. A pump (1618) is disposed within the housing to promote

movement of fluid therethrough. An influent container mating component (1620) is disposed on an exterior surface of the housing. The influent container mating component is positioned upstream of the electrodes and is in fluid communication with the electrodes. An effluent container mating component (1622) is positioned downstream of the electrodes and is in fluid communication with the electrodes. Dashed lines in **Figure 16** illustrate the flow of water out of the influent container, through the housing, and into the effluent container. Optionally, the valves (1606, 1612) are double check valves, or valves preventing flow of water therethrough when the valve is not mated to the mating component. In this way, overflow of water from the effluent valve mating component (1622) is prevented when the effluent container is not in position.

[00121] Any desirable combination of electronic controls may be used to activate the system, whether manually or by automatic sensors.

[00122] The electrodes may be positioned in a disposable container or "filter housing" within the housing (1604).

[00123] In use, this system may be used as a counter-top system on an appliance-sized scale, or may be hooked up to main water sources for a house or other type of building on a residential or industrial scale. In the case where a scaled-up version is used for a residential or industrial use, the influent and effluent containers would be sized to an appropriate scale and could be shaped as enclosed tanks or other types of holding containers. In such instances, the containers may be removable or fixed in place on the base. For large-scale applications, a constant supply of water may be provided, and the influent container may be simply a hose or pipe hooked up via the influent valve to the influent container mating component. Similarly, the effluent container may comprise a constant outflow of water to a hose or pipe hooked up via the effluent valve to the effluent container mating component.

[00124] Further, as an alternative configuration when the system is scaled up in size for larger facilities such as a residence or an industrial building, the components of the system can be placed in-line, and thus containers *per se* are not required. For example, the PEF cartridge can be placed inline on the main water inlet to a house or other building, and treat all the water entering the house.

[00125] On an appliance-sized scale, the containers may be of any convenient form, such as carafes, pitchers, pots, beakers, kettles, etc. The containers may be interchangeable, provided a valve in the lower portion of the container mates with the appropriate container mating component. The system may be scaled down to any convenient size for a desired application, such as for kitchens, laboratory bench-tops, or may be a portable system capable of being carried into the field for on-site applications. Portable systems may be applicable for industrial or research use, or for recreational use, such as to ensure a sanitized water supply while camping.

[00126] The above-described embodiments of the present invention are intended to be examples only. Alterations, modifications and variations may be effected to the particular embodiments by those of skill in the art without departing from the scope of the invention, which is defined solely by the claims appended hereto.

CLAIMS:

1. A pulsed electric field liquid sanitization system comprising:

an influent container for housing a liquid to be sanitized;

an influent valve within a lower portion of said influent container allowing passage of liquid out of said influent container;

an effluent container for housing sanitized liquid;

an effluent valve within a lower portion of said effluent container allowing passage of liquid into said effluent container;

a housing comprising pulsed electric field electrodes through which water flows to become sanitized;

a pump within the housing to promote movement of fluid therethrough; and

an influent container mating component and an effluent container mating component disposed on an exterior surface of said housing, said influent container mating component positioned upstream of said electrodes and in fluid communication with said electrodes, said effluent container mating component positioned downstream of said electrodes and in fluid communication with said electrodes.

2. The system of claim 1 wherein at least one of said influent valve and said effluent valve comprises a double check valve.

3. The system of claim 2 wherein said double check valve comprises:

an outer body having an inlet and an outlet;

first and second valve stems contained on said outer body;

the first valve stem being smaller than the second valve stem, and nested within the second valve stem, wherein said valve stems are positioned along a common axis;

the second valve stem comprising a valve seat for the first valve stem;

the outlet being the valve seat to said second valve stem; and

springs surrounding said first and second valve stems and acting on said valves to engage respective valve seats.

4. The system of any one of claims 1 to 3, wherein said housing additionally comprises a purification technology positioned between said influent container mating component and said effluent container mating component, said purification technology being in fluid communication with said electrodes.

5. The system of claim 4 wherein said purification technology is selected from the group consisting of an ion exchange resin; a filtering unit; a membrane; ozonification means; an ultraviolet (UV) light source; and aeration or oxygenation device.

6. The system of any one of claims 1 to 5, additionally comprising electronic controls for detecting the presence of an influent container or an effluent container to activate flow of liquid from said influent container, through said housing and into said effluent container so as to sanitize the liquid.

7. A water purification system comprising:

a water container comprising an upper reservoir for receiving unfiltered water, said upper reservoir comprising a lower opening; a filtering medium within the lower opening of the upper reservoir for filtering unfiltered water passing therethrough; and a lower reservoir for receiving water passed through the filtering medium, said lower reservoir having a lower opening; and

a base for receiving the water container in fluid communication with the lower opening of the lower reservoir, said base comprising a purification technology for purification of water received from the lower reservoir; and a water circulator for circulating water between the lower reservoir and the purification technology.

8. The water purification system according to claim 7, wherein said water circulator comprises a pump, connections, and electronic controls.

9. The water purification system according to claim 7 or 8, wherein the purification technology is selected from the group consisting of: electrodes for generating a pulsed electric field; an ion exchange resin; a filter; a membrane; ozonification means; an ultraviolet (UV) light source; and an aeration or oxygenation device.

10. The water purification system of claim 7, 8 or 9, wherein said filtering medium within said water container is selected from the group consisting of: a granulated activated carbon (GAC) cartridge; an extruded carbon sheet between layers of fabric material; an ion exchange resin; and one or more layers of fabric material.

11. The water purification system of any one of claims 7 to 10, additionally comprising a double check valve within the lower reservoir of the water container allowing simultaneous flow of water out of and into the lower reservoir.

12. The water purification system of claim 8, wherein said electronic controls comprise an auto-sensing circuit to detects the presence of the filtration device on the base, to activate a water flow program, and to illuminate a ready light when water purification is complete.

13. The water purification system of claim 8 or 12, wherein said electronic controls allow activation of a water flow program when a user pushes a start button.

14. The water purification system of claim 12, wherein said water flow program comprises a treatment period controlled by time and/or concentration, said treatment period consisting of:

a) drawing water from the lower reservoir via a pump,

b) pumping water past the purification technology,

c) directing water back into the lower reservoir; and

d) communicating a signal to a user indicating that the water container can be removed from the base.

15. The water purification system of any one of claims 7 to 13, wherein said filtering medium is located above and not extending into the lower reservoir.

16. A stand-alone drinking water purification device comprising:

an upper reservoir for receiving unfiltered water, said upper reservoir having a lower opening;

a filtering medium within the lower opening of the upper reservoir for filtering unfiltered water passing therethrough, said filtering medium being selected from the group consisting of: a granulated activated carbon (GAC) cartridge; an extruded carbon sheet between layers of fabric material; and an ion exchange resin; and

a lower reservoir for receiving water passed through the filtering medium,

said filtering medium being located above and not extending into the lower reservoir.

17. A pulsed electric field liquid sanitization system comprising:

an inlet for interfacing with an influent water source to be sanitized;

an outlet for interfacing with an effluent sanitized water receiving means;

a housing comprising pulsed electric field electrodes through which water flows to become sanitized, said housing having the inlet and the outlet disposed thereon, said inlet being positioned upstream of said electrodes and in fluid communication with said electrodes, said outlet being positioned downstream of said electrodes and in fluid communication with said electrodes.

14. The water purification system of any one of claims 7 to 13, wherein said filtering medium is located above and not extending into the lower reservoir.

15. A stand-alone drinking water purification device comprising:

an upper reservoir for receiving unfiltered water, said upper reservoir having a lower opening;

a filtering medium within the lower opening of the upper reservoir for filtering unfiltered water passing therethrough, said filtering medium being selected from the group consisting of: a granulated activated carbon (GAC) cartridge; an extruded carbon sheet between layers of fabric material; and an ion exchange resin; and

a lower reservoir for receiving water passed through the filtering medium,

said filtering medium being located above and not extending into the lower reservoir.

16. A pulsed electric field liquid sanitization system comprising:

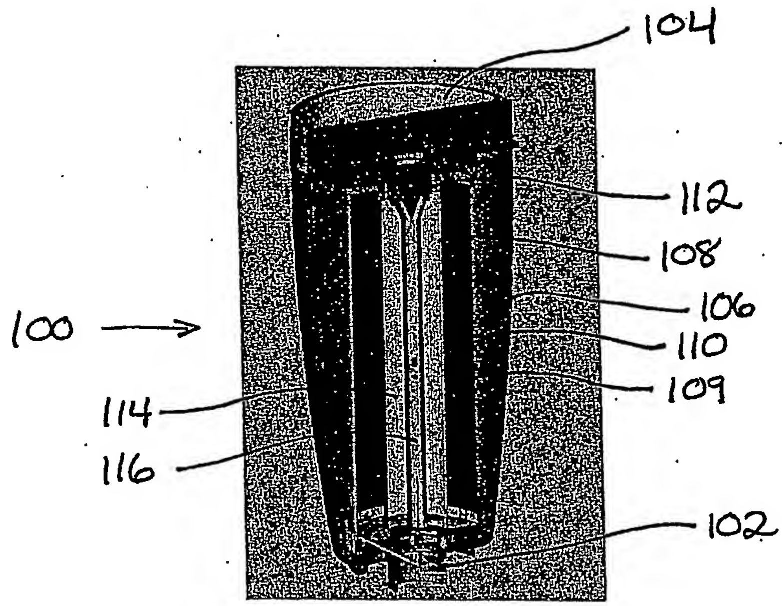
an inlet for interfacing with an influent water source to be sanitized;

an outlet for interfacing with an effluent sanitized water receiving means;

a housing comprising pulsed electric field electrodes through which water flows to become sanitized, said housing having the inlet and the outlet disposed thereon, said inlet being positioned upstream of said electrodes and in fluid communication with said electrodes, said outlet being positioned downstream of said electrodes and in fluid communication with said electrodes.

ABSTRACT

The invention relates to a pulsed electric field sanitization system that may be used for sanitization of liquids, such as drinking water. The system optionally includes a double check valve to allow simultaneous flow of water into and out of components of the system. The system may be used in combination with other purification technologies. A further embodiment of the invention relates to a stand-alone drinking water purification device.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116
102

FIG. 1

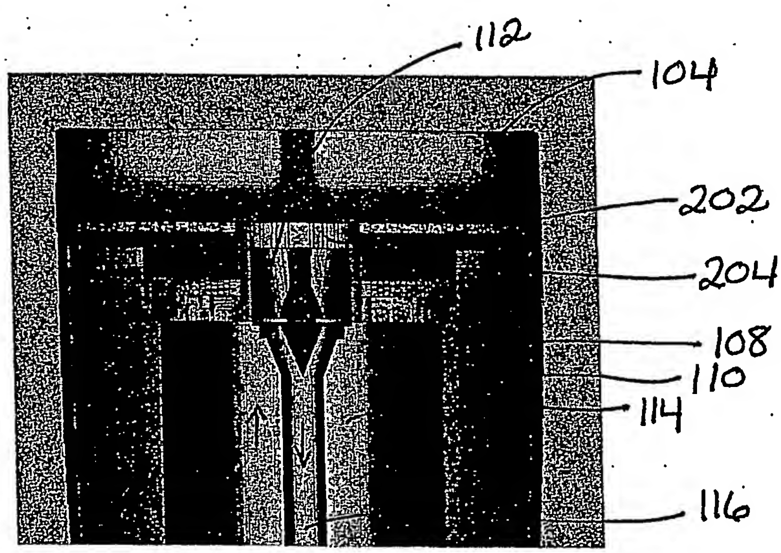
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FIG. 2

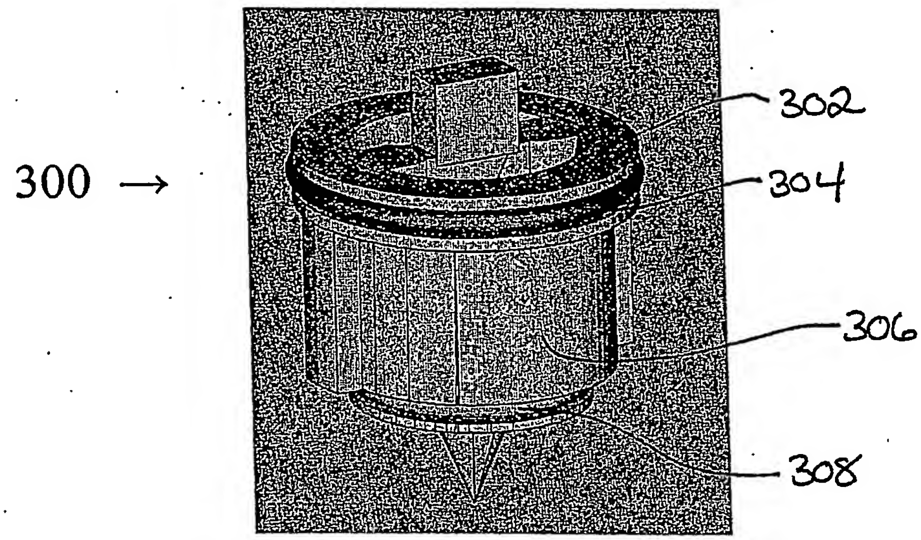

FIG. 3

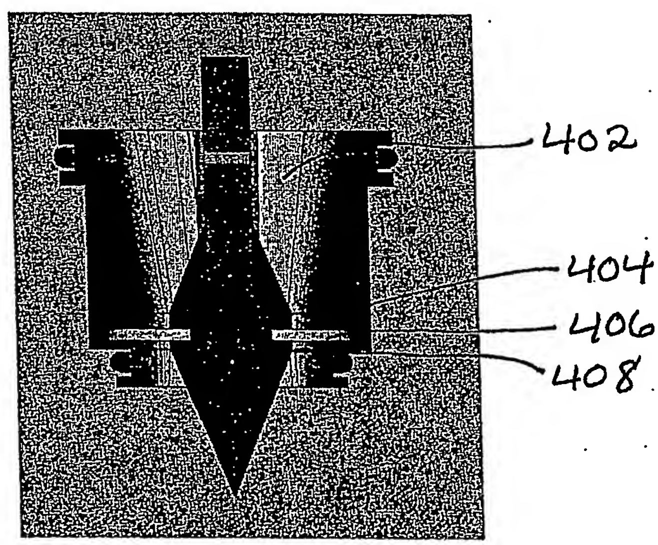

FIG. 4

.tran 0 1e-4 0 1e-8 startup uic
.param mut=.99 transformer coupling
K1 L1 L2 {mut}
tran-out
R3
1e6
L1
10e-4
L2
10e-1
V1
R1
35K
PULSE(-160 +160 0 1e-7 1e-7 20e-6 40e-6)
C1
Cap-V
.05e-6
V(tran-out)
I(R1)
8KV
7KV
6KV
5KV
4KV
3KV
2KV
1KV
0KV
-1KV
-2KV
-3KV
-4KV
-5KV
-6KV
-7KV
-8KV
300mA
250mA
200mA
150mA
100mA
50mA
0mA
-50mA
-100mA
-150mA
-200mA
-250mA
-300mA
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90µs
100µs

FIG. 5

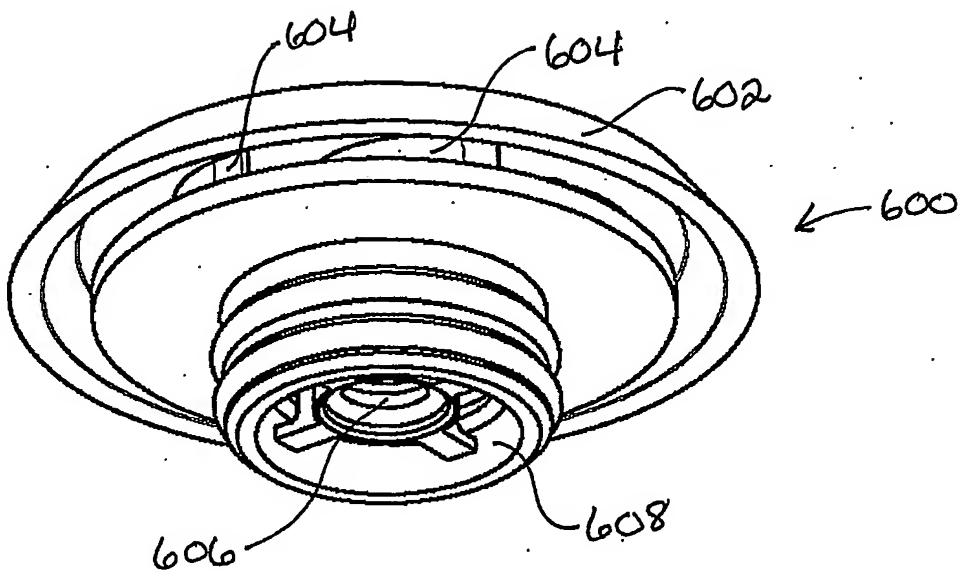


FIG. 6

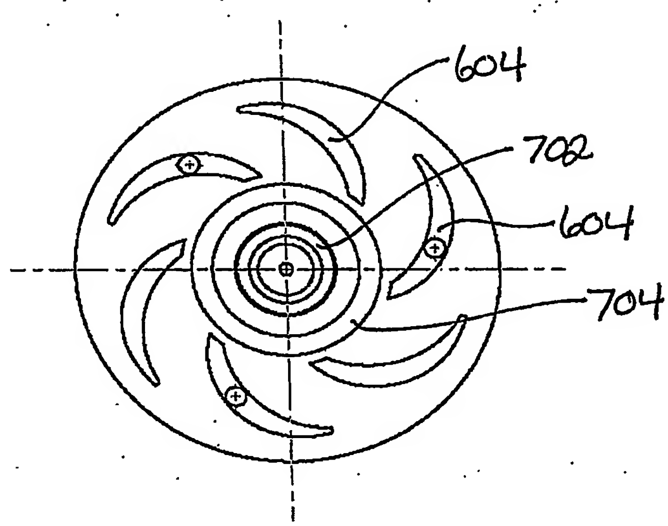
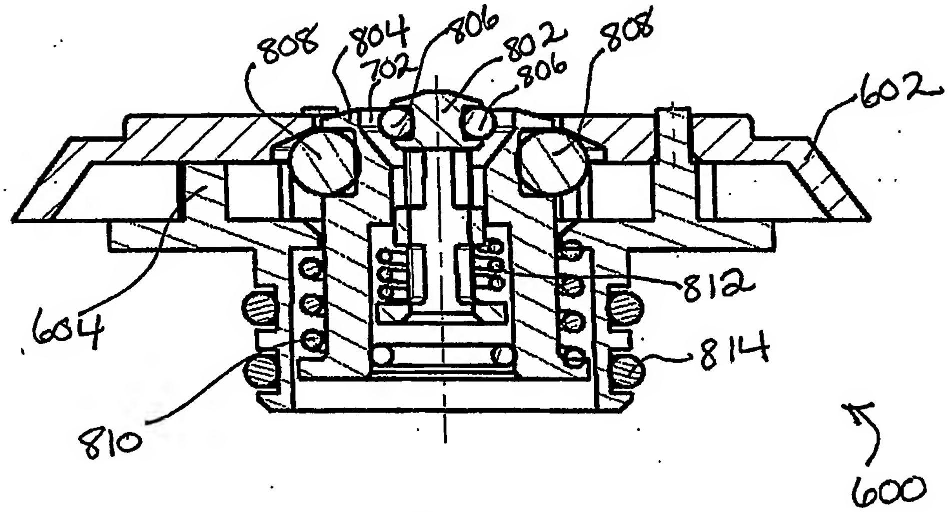


FIG. 7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808
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812
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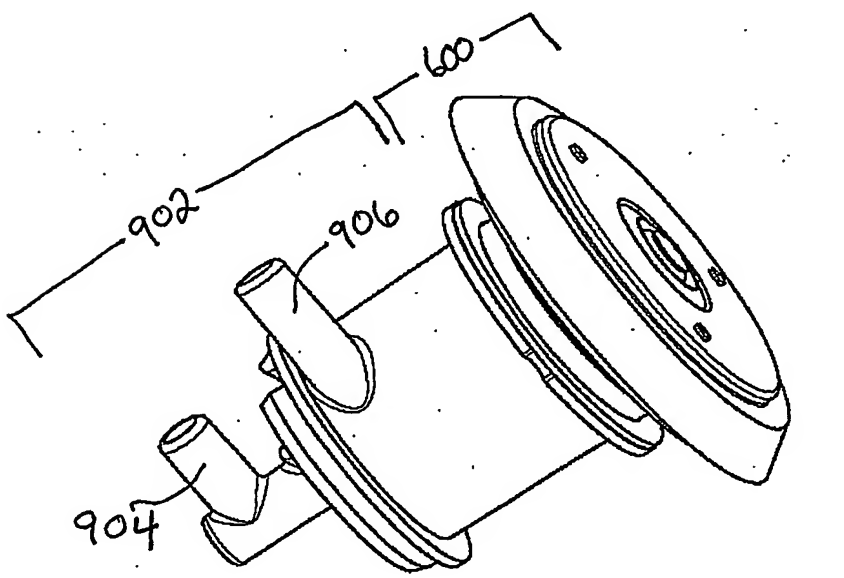
810
600

FIG. 8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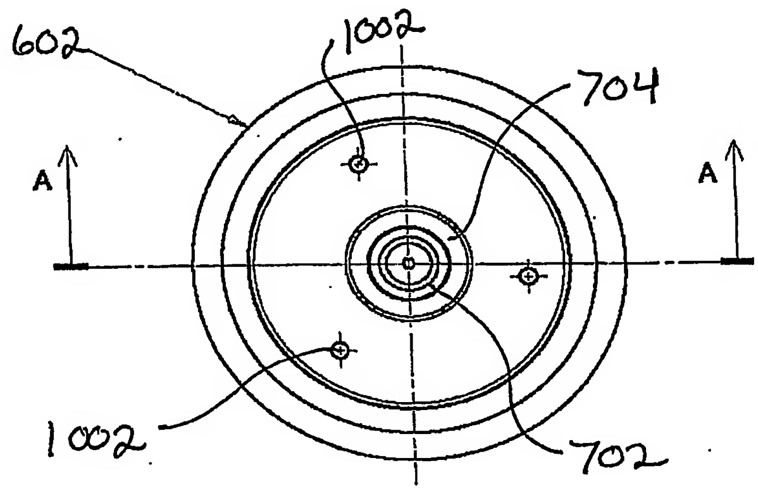
906
904

FIG. 9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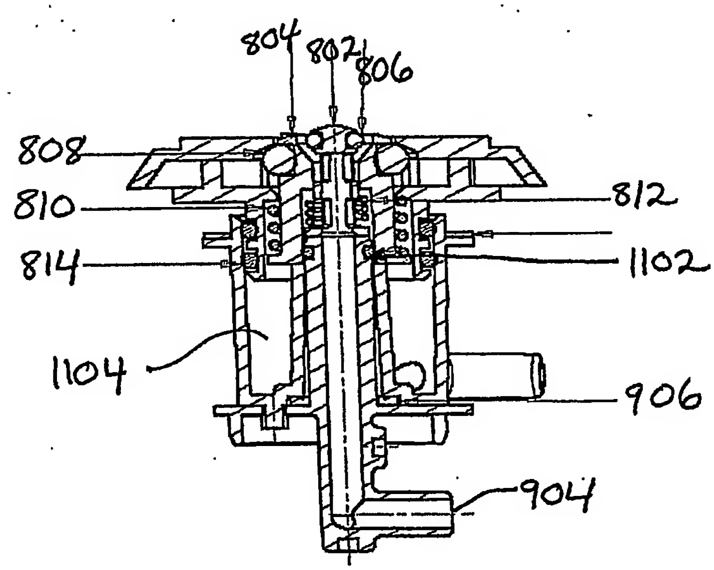
704
A
A
1002
702

FIG. 10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1104
906
904

FIG. 11

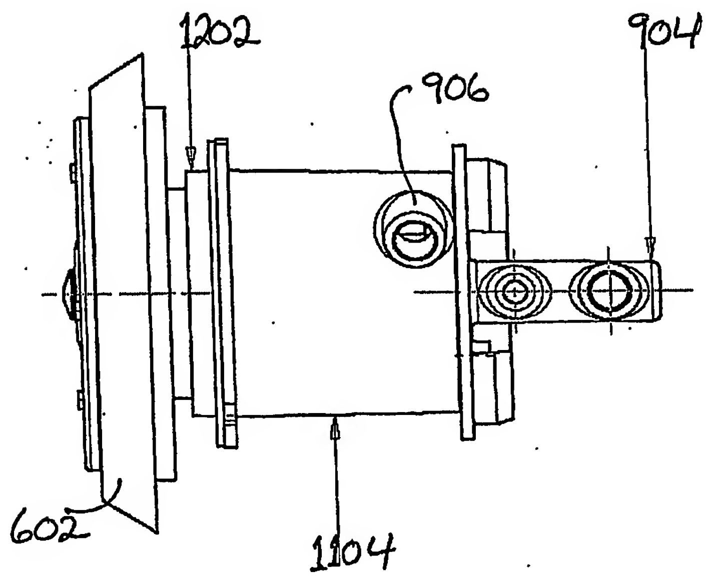

1202
904
906
602
1104

FIG. 12

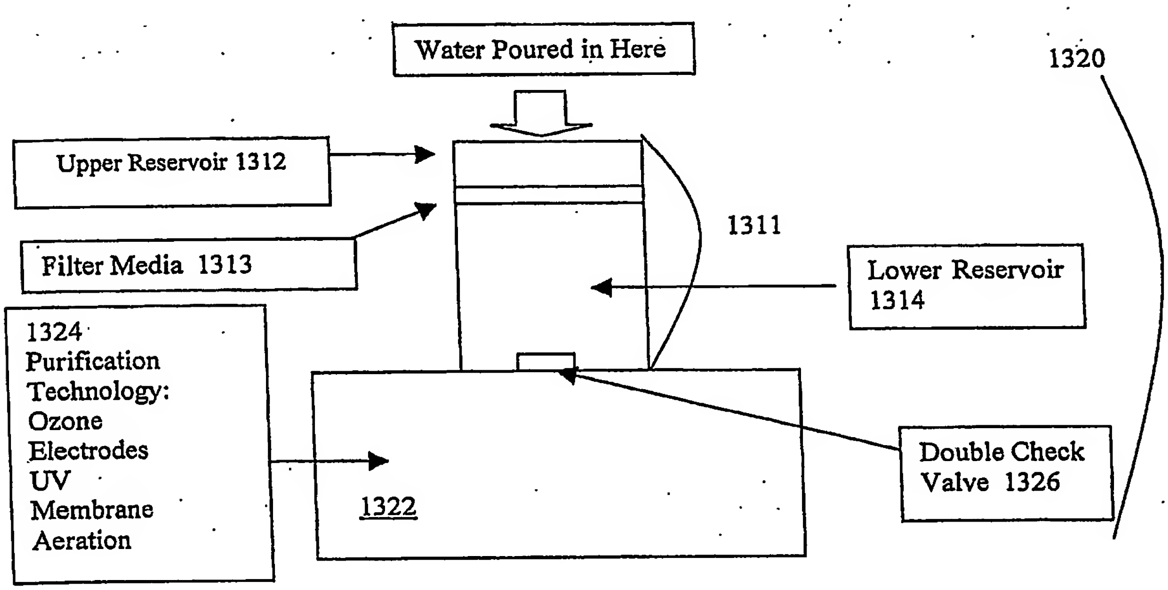
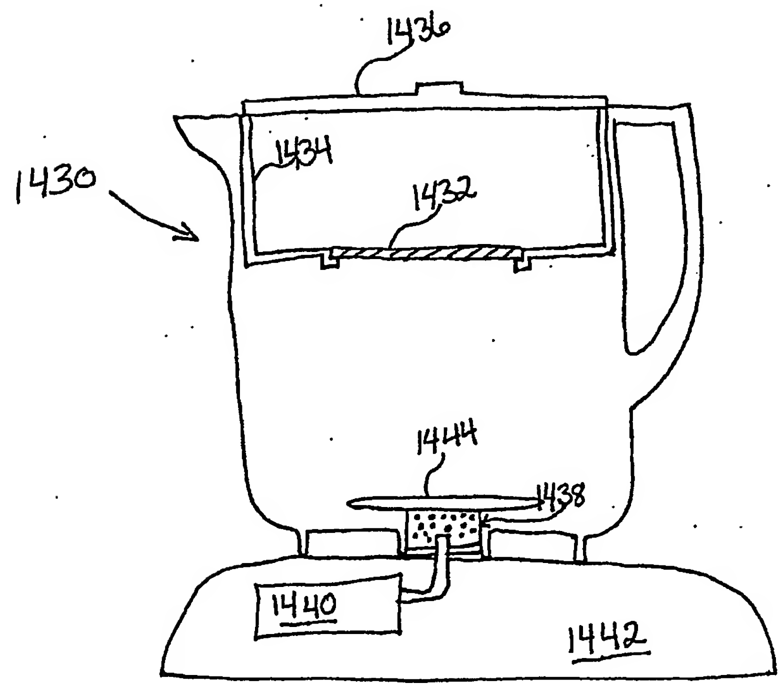

Water Poured in Here
1320
Upper Reservoir 1312
1311
Filter Media 1313
Lower Reservoir 1314
1324
Purification Technology:
Ozone
Electrodes
UV
Membrane
Aeration
1322
Double Check Valve 1326

FIG. 13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1434
1432
1444
1438
1440
1442

FIG. 14

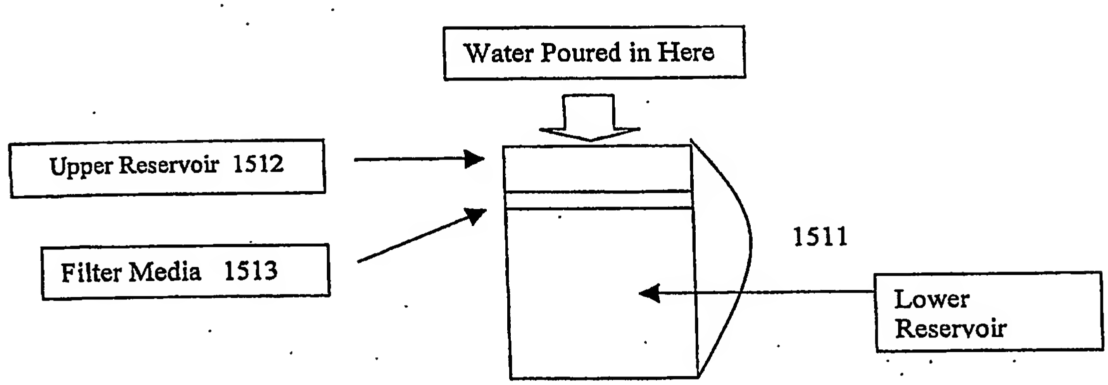
Water Poured in Here
Upper Reservoir 1512
Filter Media 1513
1511
Lower Reservoir

FIG. 15

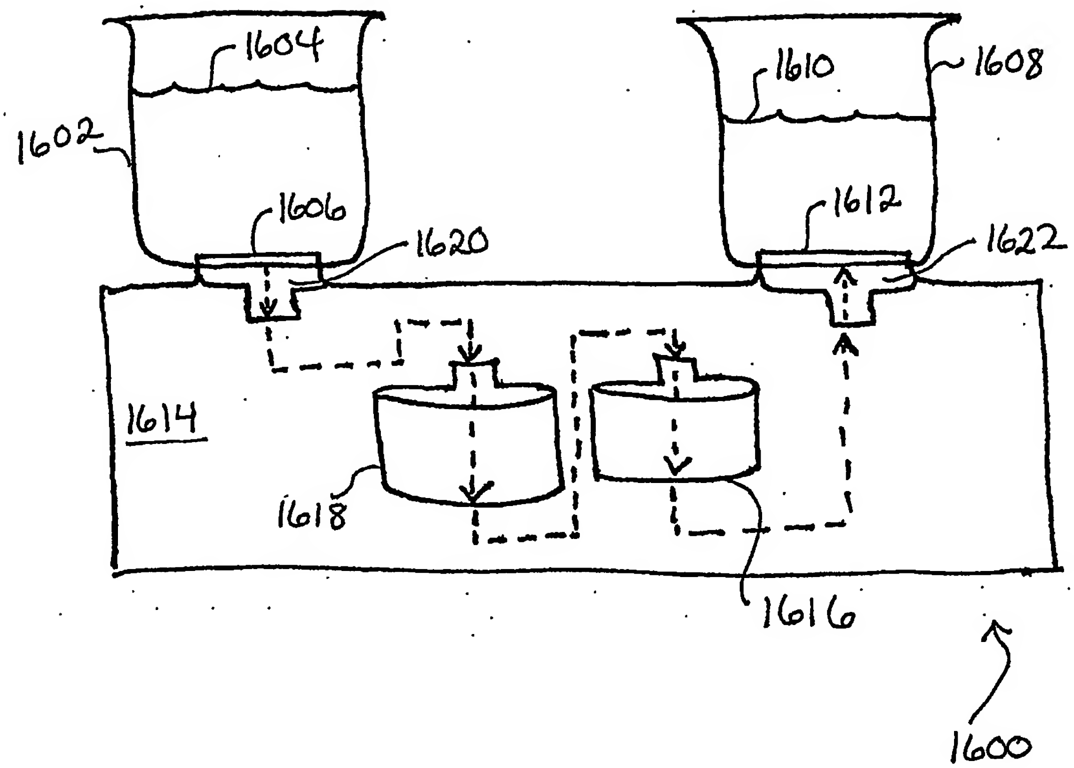

FIG. 16